

[54] **PRESSURE RELIEVING LINEAR MOTION VALVE**

[56]

**References Cited**

**U.S. PATENT DOCUMENTS**

3,842,943 10/1974 Nakamura et al. .... 91/454 X  
 4,239,179 12/1980 Geier ..... 251/129.11 X  
 4,318,332 3/1982 Shingu et al. .... 91/446 X

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[21] **Appl. No.:** **853,286**

[57]

**ABSTRACT**

The point at which pump out pressure exceeds load is sensed to provide a point for scheduling flow to an actuator in a hydraulic system. Flow is controlled by a stepper motor (28) that moves a flow control valve (27). The steps needed to achieve fixed flow changes are greater for high flow positions. When the pump (21) is turned on, the valve (27) is positioned to bypass flow; the bypass flow is then programmably decreased to the actuator. Reverse flow is regulated by the valve (27) to control actuator retraction. Reverse flow is initiated by opening a check valve (40) with an actuator (50) that opens it first to reduce pressure across the valve, then fully. The flow control valve (27) also operates to relieve excess pressure in the system.

[22] **Filed:** **Apr. 17, 1986**

**Related U.S. Application Data**

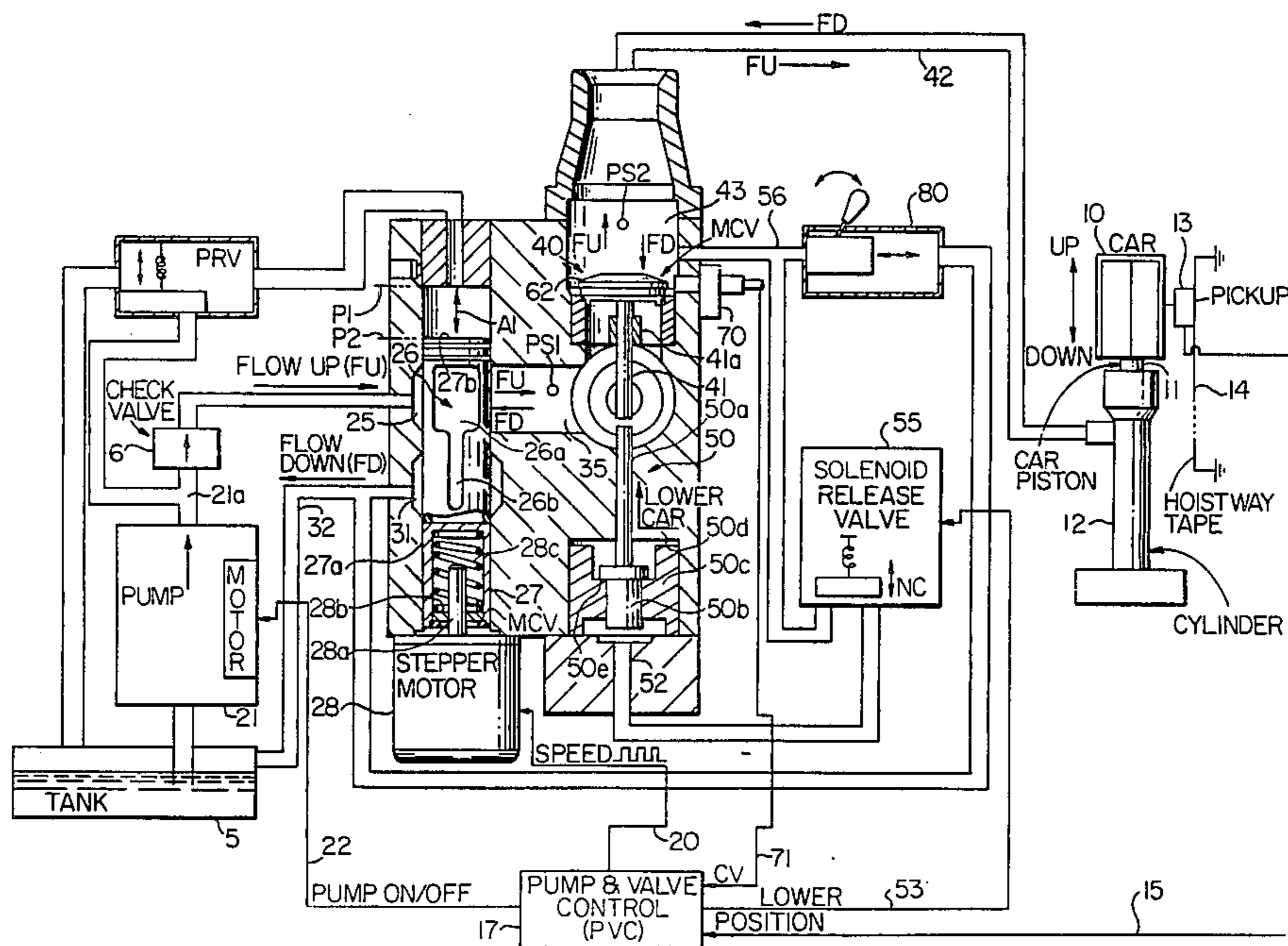
[63] Continuation-in-part of Ser. No. 799,765, Nov. 18, 1985, abandoned.

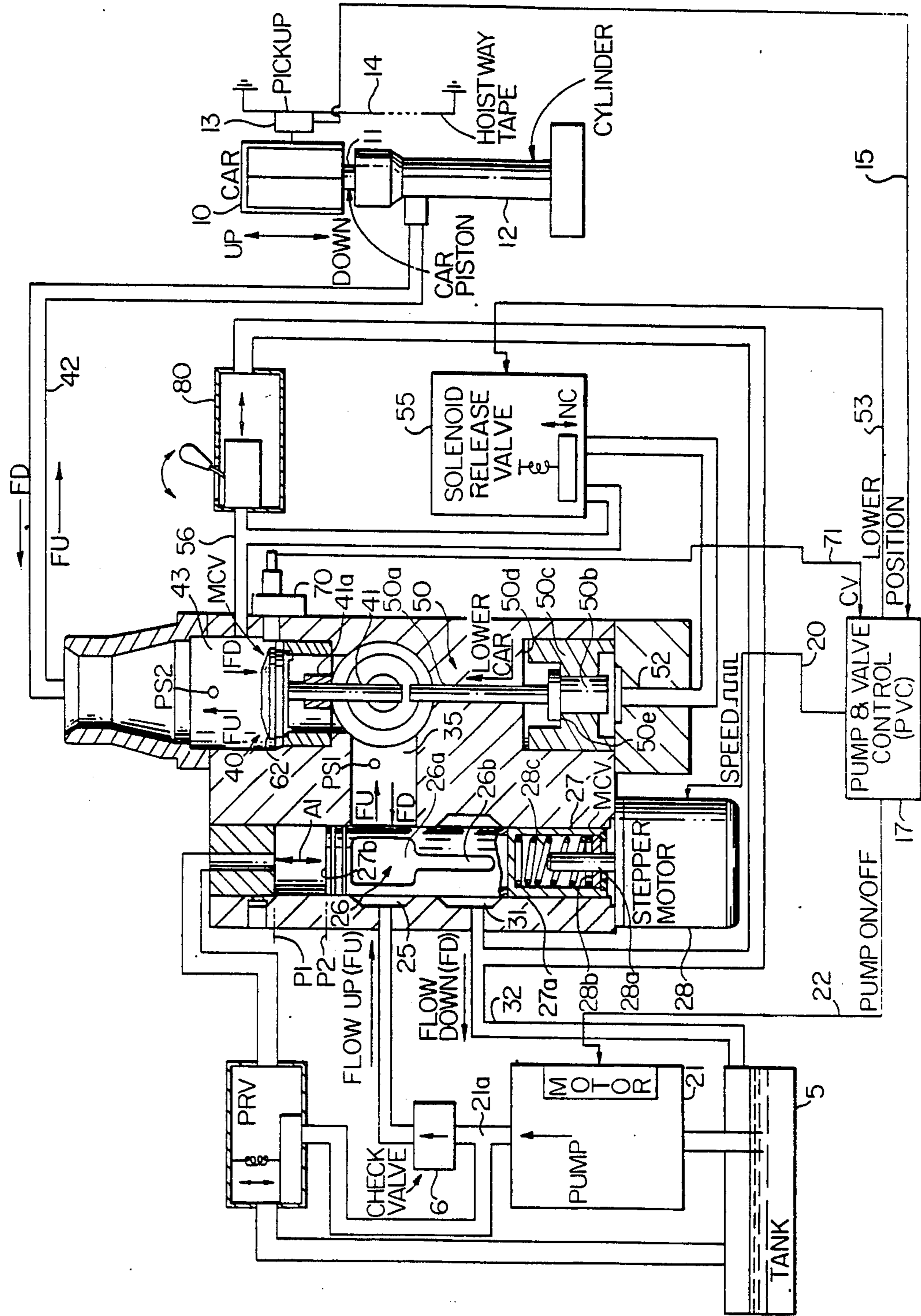
[51] **Int. Cl.<sup>4</sup>** ..... **F15B 13/044**

[52] **U.S. Cl.** ..... **137/115; 91/446; 91/459; 137/488; 137/625.3; 187/110; 251/129.11**

[58] **Field of Search** ..... **91/446, 459; 137/115, 137/488, 522, 554, 596.12, 625.3, 625.38, 877; 187/29 A, 29 B; 251/63.4, 129.05, 129.11**

**2 Claims, 1 Drawing Figure**





## PRESSURE RELIEVING LINEAR MOTION VALVE

This is a continuation-in-part of Ser. No. 799,765, 5  
filed Nov. 18, 1985, now abandoned.

### CROSS-REFERENCE TO RELATED CASES

This application shows apparatus described and  
claimed in the application titled "Pressure-Referenced 10  
Programmed Flow Control in a Hydraulic Valve", U.S.  
Ser. No. 799,665, now abandoned, and the application  
titled "Hydraulic Elevator with Dynamically Pro-  
grammed Motor-Operated Valve", U.S. Ser. No.  
799,666, now abandoned, by the same inventors and 15  
also assigned to the same assignee, Otis Elevator Com-  
pany.

### TECHNICAL FIELD

This invention concerns hydraulic valve control sys- 20  
tems and, in particular, those used in hydraulic eleva-  
tors.

### BACKGROUND ART

In an attempt to control a hydraulic elevator with 25  
precision approximating the more sophisticated and  
usually more expensive traction elevators, feedback  
control is used. But, even using feedback control, com-  
parable performance has been difficult to achieve. The  
main problem is the dynamic characteristics of the fluid; 30  
its viscosity shifts with the ambient temperature and  
also from the heating that occurs as the elevator car is  
raised and lowered. These variables produce some mea-  
sure of unpredictability in the motion of the elevator  
car. Different levels of feedback have been utilized, but 35  
typically these are expensive and lower system effi-  
ciency by requiring excess pump capacity.

A technique illustrating feedback is shown in U.S.  
Pat. No. 4,205,592, where the flow through the valve 40  
and to an object, such as a hydraulic elevator, is passed  
through a flow meter that includes a potentiometer. As  
the flow increases, the output voltage associated with  
the motion of the potentiometer wiper changes, mani-  
festing the magnitude of the flow. U.S. Pat. No.  
4,381,699 shows a similar type of valve control. 45

U.S. Pat. No. 4,418,794 is illustrative of the type of  
valve that may be used in systems that do not sense the  
fluid flow but, using a larger feedback loop, perhaps  
sense the position of the elevator car and control the  
operation of the valve. 50

### DISCLOSURE OF INVENTION

According to the present invention, a pump is acti-  
vated to apply fluid under pressure to a hydraulic valve  
that controls the flow of the fluid between a hydraulic 55  
actuator, such as the cylinder in a hydraulic elevator,  
the pump and the tank from which the pump draws the  
fluid. This valve contains a linear motion valve that is  
moved by a stepper motor. The linear valve controls  
the flow rate to the actuator as it extends and the flow 60  
rate from the actuator to the tank as it retracts. The  
valve is moved between two positions. At one position,  
the fluid from the pump is bypassed from the actuator  
back to the fluid tank or reservoir, and fluid flow from  
the actuator is directed to the tank. At the other posi- 65  
tion, all of the flow from the pump is applied to the  
actuator, to extend the actuator. Fluid flows from the  
actuator back to the tank through the linear valve,

which is moved to control the reverse flow rate as the  
actuator retracts. The position of the linear valve be-  
tween those two positions thereby controls the flow  
rate and the extension and retraction velocity of the  
actuator. The stepper motor moves the valve in discrete  
steps by which the position of the valve is known, by  
counting the number of steps made by the motor.

According to one aspect of the invention, the connec-  
tion between the motor and the valve is through a resil-  
ient coupling, such as a spring. This connection allows  
the valve to be moved to bypass fluid flow from the  
pump back to the tank when the valve is in a position in  
which all the pump output is directed by the valve to  
the actuator. A pressure release valve is operated when  
the pump pressure exceeds a certain level, and that  
operation applies fluid under pressure to the valve,  
which, in response, moves against the resilient coupling  
to connect the pump output to the tank. This valve  
operation relieves the pump pressure.

### BRIEF DESCRIPTION OF THE DRAWING

The drawing is a schematic showing a hydraulic  
elevator control system embodying the present inven-  
tion.

### BEST MODE FOR CARRYING OUT THE INVENTION

FIG. 1 shows a hydraulic elevator control system for  
moving an elevator car 10 between a plurality of floors  
or landings. The floors or landings are not shown. The  
car is attached to a car piston (plunger) 11 that extends  
from a cylinder 12, and fluid is pumped into or dis-  
charged from the cylinder to raise and lower the car  
respectively, that flow being controlled and regulated  
in a manner that will be described in detail. The motion  
of the car is detected by a pickup 13. Associated with a  
stationary position tape 14, the pickup provides a signal  
(POSITION) on line 15 that is supplied to a pump and  
valve control (PVC) 17. The POSITION signal mani-  
fests the car position and velocity. The position of the  
car thus sensed is used for controlling the flow of fluid  
between the cylinder, controlling the position of the  
car piston or plunger 11. The PVC 17 controls a hydraulic  
valve system that includes a pump 21 and a fluid reser-  
voir (tank) 5. The pump supplies fluid to a hydraulic  
control valve assembly through a check valve 6 (to  
prevent back flow), and this assembly is controlled,  
along with the pump, by the PVC 17. The pump is  
turned on or off (activated/deactivated) by a pump  
on/off signal on a line 22, and the fluid from the pump  
is applied under pressure through the check valve 6 and  
then to a first port 25. 50

The port 25 leads to a "key-shaped" valve window 26  
that is part of a linear valve 27, one that moves back and  
forth linearly between two positions P1, P2. The posi-  
tion of the valve 27 is controlled by a stepper motor 28  
which receives a signal (SPEED) on the line 20 from  
the PVC 17. That signal comprises successive pulses,  
and the frequency of those pulses determines the mo-  
tor's 28 speed; hence also the longitudinal (see arrow  
A1) rate of positioning of the valve 27. Each pulse in the  
SPEED signal represents an incremental distance along  
the length of motion of the valve 27 between points P1  
and P2. The position (location) of the valve is repre-  
sented by the accumulated count between those posi-  
tions. The valve window 26 comprises a large window  
26a and an adjacent narrower window 26b, giving it a  
"key-shaped" appearance. At one point, P2, the large

window 26a is adjacent the first inlet port 25, and the narrower adjacent portion 26b is located next to a second port 31. At this point, the valve 27 is "open". That second port 31 leads to a line 32 that goes to the tank 5. At position P1, the small window 26b is mostly adjacent to the port 25, and the path to the port 31 is blocked by the solid part of the valve. At that position, the valve 27 is "closed". In the open position, at P2, fluid flows from the pump through the line 21a; this is "flow-up" (FU), flow to raise the car. The fluid then passes into the large window 26a and, from there, through the small window 26b back to the line 32, then to the tank. The FU flow is thus bypassed when the pump is started. But, as the valve 27 closes (moves to position P1), the pressure of the FU fluid flow begins to build in an internal port 35, while the bypass flow on line 32 decreases as the path through window 26b to port 31 decreases. As the valve 27 moves to position P1 (nonbypass position), there is some overlap of the two windows 26a, 26b and the main inlet port 25, meaning that the path through the large window 26a decreases, while the path through the smaller window 26b increases. But, the area of the smaller window 26b is more dependent than with the case of the larger window on the longitudinal position of the valve 27. As a result of this, the change in flow is controlled by the smaller valve window area to outlet port 31, which reduces as the main valve begins to move towards the closed position at P1, at which all the FU flow passes from the port 25 to the inlet 35; there being no path between the port 25 and the outlet port 31.

The fluid pressure PS1 in the internal port 35 is applied to a main check valve (MCV) 40. This valve has a small stem 41 that rests in a guide 41a. The MCV may freely move up and down in response to the pressure differentials between the port 35 and the port 43, where the pressures are PS1 and PS2, respectively. When the pump is turned on and the main valve 27 closes, moves towards position P1, the MCV 40 is pushed upward when PS1 exceeds PS2, allowing the FU flow to pass through the MCV into the line 42 that extends to the cylinder 12. This happens as the bypass flow decreases. The resultant fluid flow displaces the car piston 11 upward, moving the car in the same direction.

When the car 10 is at rest, pressure in the line 42 and the pressure in the chamber 43 are the same, pressure PS2. With the pump 21 off, this pressure pushes the MCV 40 down, and the down flow (FD) in the line 42 is then blocked, holding the car 10 in position. No flow through the line 42 and back to the tank 5 is possible under this condition. To allow this flow to occur, the MCV 40 must be lifted, and this is effected by the operation of a main check valve actuator 50.

This actuator includes a rod 50a, which contacts the stem 41 when pushed upward; a first member 50b which is pushed upward against the rod; a second member 50c which when pushed upward moves the first member. The rod 50a is thrust upward, pushing the MCV 40 upward, when fluid, at pressure PS2, is applied to the inlet line 52, and that happens only when a LOWER signal is applied to the line 53 that goes to a solenoid control release valve 55. The fluid pressure in the line 52 is then applied to the bottom of the members (pistons) 50b, 50c. The combined surface area of those members is greater than the upper surface area 62 of the valve 40. The second member moves until it strikes the wall 50d. The first member also moves with the second member because of the flange 50e. This small motion (as

far as the wall 50d) "cracks" open the MCV 40, equalizing the pressures PS1 and PS2. Then the first member continues to move upward, until it too strikes the wall, fully opening the MCV 40. This allows return flow (CFD) from the chamber 35 that passes through the windows 26a, 26b, and line 32. The FD flow through line 25 is blocked by the check valve 6. The position of the valve 27 determines the rate of the FD flow, thus the speed profile of the car as it descends. The valve is moved from the closed P1 position by the SPEED signal towards the open position P2. The duration and frequency of the SPEED signal sets the down velocity profile.

There is switch 70 that is adjacent the MCV 40, and the upward motion of the MCV 40 causes the switch to operate. That operation provides a signal (CV) on the line 71 going to the PVC 17. The CV signal shows that the valve in the up direction for elevator travel has moved. It represents that the pressure in the chamber 35 has slightly exceeded the pressure in the chamber 43. Using this signal, the PVC may control the further motion of the valve spool by controlling the pulse rate and duration comprising the SPEED signal, which is applied to the line 20. The CV signal occurs just when the pressure of PS1 35 exceeds the pressure PS2, and that occurs just before there is actual flow. Generation of the CV signal consequently provides a definitive manifestation of "anticipated" flow.

The stepper motor controlled valve 27 also provides a pressure release function for the port 35. The stepper motor 28 has an output link 28a, and a collar or ring 28b is attached to that link. The link and collar fit in a hollow portion of the valve 27 but separated from the flow area (windows 26a, 26b) by the valve wall 27a. (The valve 27 is shaped like a hollow cylinder, and fluid flows through its interior). A spring 28c fits between the wall and the collar 28b. As the stepper motor operates, the link moves up or down, in steps corresponding to the steps in the SPEED signal. This motion is transmitted to the wall 27a through the spring to the valve 27, which moves in synchronism with the link. If the pressure in the pump output line 21a is sufficient to operate the pressure release valve (PRV), the pressure is applied to the top of the valve 27b, the entire valve 27 is forced down, allowing the flow from the pump through line 21a to pass through the interior of the valve (through the windows 26a, 26b), then through the line 32 to the tank 5, to relieve the "overpressure" condition.

For manually lowering the car, a manually operated valve 80 is operated to allow the fluid to flow from the chamber directly back to the tank 5.

The preferred embodiment of the invention has been described, and one of ordinary skill in the art to which the invention relates may make modifications and variations to that embodiment, in whole or part, without departing from the true scope and spirit of the invention.

We claim:

1. A hydraulic valve comprising:
  - a main inlet adapted for connection to a pump;
  - a main outlet adapted for connection to an actuator comprising a piston and a cylinder;
  - a secondary outlet adapted for connection to a fluid tank;
  - a flow control valve for controlling fluid flow from the main inlet to the main outlet;
 hydraulic valve being characterized by:

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the flow control valve being continuously movable between two positions to control progressively, from a minimum to a maximum equalling the pump output, the flow between the main inlet and the main outlet and discharge from the main outlet to the tank, at one position the main inlet and secondary outlet being connected, at the other position the main inlet and the main outlet being connected and the main inlet and secondary outlet being disconnected;

a motor for moving the valve linearly in discrete steps;

a resilient member interconnecting the motor and one end of the valve;

the motor applying force through the resilient member to move the valve to said one position and to hold the valve in any position against the pressure

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on the valve by the fluid in the main outlet from the main outlet; and

a pressure operated valve connected to the pump output and the flow control valve;

the flow control valve being movable against the force of the resilient member to said other position when the valve is at said one position in response to fluid applied thereto by the pressure operated valve when the pump output pressure exceeds a certain level.

2. A valve according to claim 1, characterized by: the main valve comprising a hollow cylinder with windows through which fluid enters and leaves the interior of the cylinder, said resilient member being disposed between the motor and one end of the cylinder, and the other, opposite end being located in a chamber connected to the pressure operated valve.

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